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JAN 79 P A HOWDYSHELL, T OLSSON

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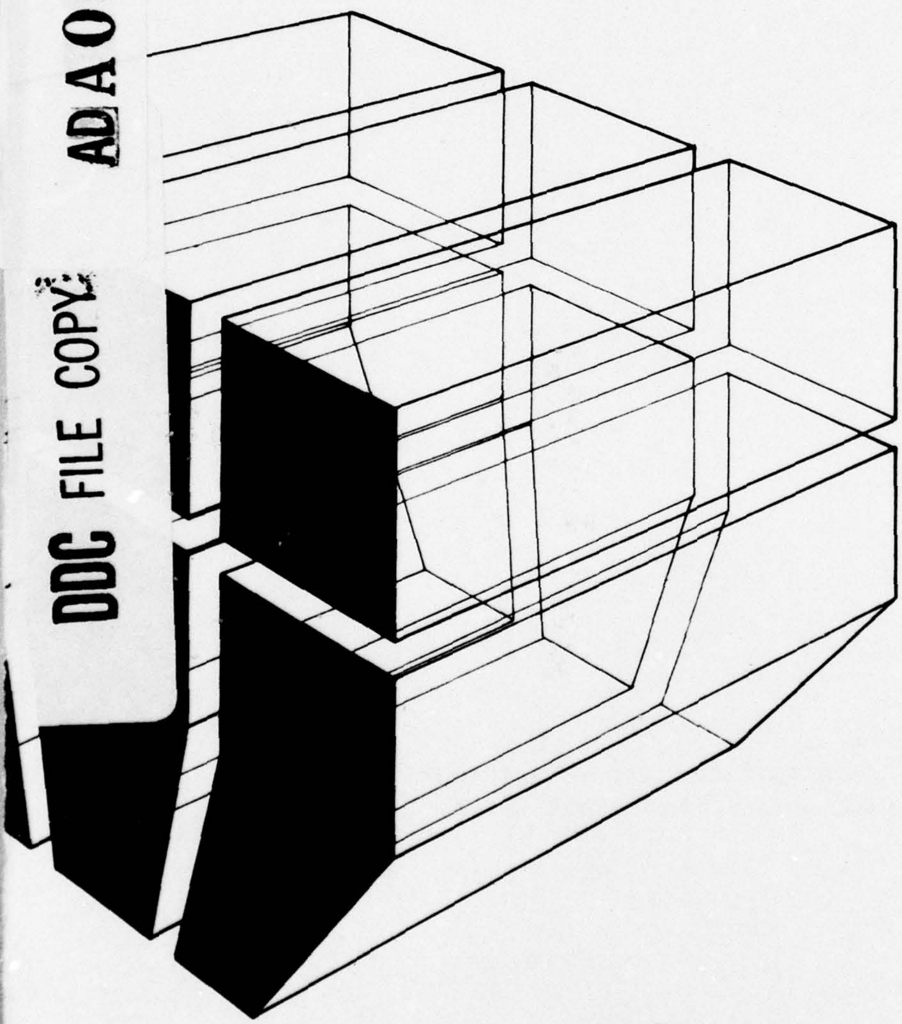
January 1979
Rapid Surface Preparation Techniques

INVESTIGATION OF TECHNIQUES FOR THE RAPID PREPARATION OF PAINTED WOOD SURFACES



by
P. A. Howdyshell
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The major contributing factor to paint failure is excessive buildup of multiple coats of paint applied over a period of years. Although old paint can be removed adequately before repainting, the classical removal processes are costly and impractical. This study examines equipment which, according to the claims of the manufacturers, removes paint easily and inexpensively from wooden surfaces. In addition, tests were conducted to determine the feasibility of developing equipment to remove paint through microwave heating.

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Four systems were evaluated and/or tested: a high-pressure water/sandblasting system, a steam-propelled sandblasting system, a hot air torch system, and microwave heating.

The results of the program indicated that none of the systems evaluated could completely remove the paint from wood structures without substantially damaging wood substrate. Results indicated, however, that high-pressure water and water/sandblasting systems may be effective in cleaning surfaces and removing loose paint.

FOREWORD

This research was conducted for the Directorate of Facilities Engineering, Office of the Chief of Engineers (OCE) under Project 4A7627314AT41, "Design, Construction, and Operation and Maintenance Technology for Military Facilities," Task T9, "Facilities Operation and Maintenance Management," Work Unit 028, "Rapid Surface Preparation Techniques." The work was performed by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (CERL). Dr. G. R. Williamson is Chief of EM. The OCE Technical Monitor was Mr. J. Rimmer, DAEN-MPO-B.

COL J. E. Hays is the Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

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PREPARATION OF PAINTED WOOD SURFACES

1 INTRODUCTION

Background

The most difficult paint problems facing facility engineers on Army installations are World War II mobilization buildings. These wood structures, constructed during the early 1940's, were expected to last approximately 10 years. However, many are still in use today. Most of these buildings are painted every 3 to 5 years; over a 35-year period they have accumulated many coats of paint. These thick, multiple coats cause cracking, peeling, and eventual failure.

There is no single reason for this paint failure; it results from many factors working in combination. The two most important factors are:

1. Moisture. The thicker the paint film, the more it resists the passage of water vapor. Thin paint films permit the passage of naturally occurring moisture; however, as more and more coats of paint accumulate over a period of years, the permeability of the paint film is reduced to such a degree that excessive moisture accumulates behind the paint film, loosening it from the substrate. When moisture cannot pass through the paint film, the moisture content of the wood is raised, causing the wood to expand.

2. Chemical Changes. Paint films do not maintain chemical stability once they are dry -- they are constantly oxidizing at a slow rate and otherwise changing chemically. The result is paint films which become increasingly brittle with age. When changes take place in the substrate, such as an expansion of wood caused by moisture accumulation, old paint films are more prone to failure than newer, more flexible films. These older paint films expand and contract with changes in moisture content and temperature, and different layers of paint expand and contract at different rates depending on age and type of paint.

The factors outlined above contribute significantly to paint failure. Their effects can, however, be mitigated if multicoat paint applications are avoided. A surface which is carefully prepared for repainting, i.e., stripped clean of previous coats of paint, is less prone to failure. In fact, complete removal of old paint prior to repainting wooden surfaces can result in superior paint performance.

There are four classical methods of paint removal: heating, chemical removers, sanding, and blast cleaning. None of these methods are considered practical for preparing exterior wood surfaces for painting because of the following:

1. Heating. Although this is a satisfactory method of paint removal, it is time consuming. A hand-held torch is used to heat and soften paint on the surface being cleaned, while a hand-held scraper is used, simultaneously, to scrape heated paint off while it is still soft. Removal by this method is fairly complete, and although some surface charring occurs, the substrate is clean enough to accept a primer and subsequent topcoats. (Although individual home owners frequently use this method, it is normally too costly when salaried contractor's employees are doing the work.) Application of heat, particularly by torch, constitutes a fire hazard.

2. Chemical Removers. Chemical removers are easily absorbed into porous substrate materials such as fir or pine; once absorbed, the removers will attack any paint subsequently applied to the substrate. As a result, chemical removers are impractical for standard surface preparation tasks such as removing paint from wood siding. (Since wood siding is inherently porous, it will quickly absorb a chemical remover; it is also impossible to completely remove the chemical from all the cracks and crevices in the siding.) Chemical removers have adverse effects on the environment.

Chemical removers can be as expensive as the paint itself, excessively messy, and work slower than heating with a torch. In addition, all of the types currently on the market are irritating to the skin and eyes. Chemical removers are only of value when preparing the surfaces of small items or very costly structures such as aircraft.

3. Sanding. Sanding is a very slow method of paint removal which is usually accomplished with a power disc sander. Since a paint film becomes much harder than the wood siding substrate, once the abrasive disc has worn the paint film away, the wood siding is easily damaged. This method has the further disadvantage of not being efficient in removing paint from irregular surfaces such as the ship lap-siding typically used on Army buildings.

4. Blast Cleaning. Sandblasting will remove paint very efficiently if the substrate is harder than the paint film. However, when the paint film has been eroded away by the sandblast process, it is very difficult or impossible to control rapid damage to the softer wood substrate.

Surface preparation usually accounts for half or more of the labor cost of a maintenance paint job. Because painting contracts are traditionally awarded to the low bidder, surface preparation performed by painting contractors is often inadequate.

The maximum surface preparation performed by contract on Army buildings usually involves only hand wire-brushing, light sanding, or surface washing to remove loose paint and chalk. In some cases peeled or blistered areas are "feather edged" by hand sanding. Because these surface preparation methods are incomplete, new paint jobs are prone to premature failure. There is no reliable, practical method of removing old paint prior to painting without an excessive increase in surface preparation costs.

Purpose

The purpose of this study was to evaluate recently developed surface preparation equipment, and to investigate the possibility of developing new equipment for paint removal by microwave heating.

Approach

A literature search was conducted to identify equipment which could be adapted to the paint removal needs of the facilities engineer. Equipment manufacturers were contacted to determine equipment effectiveness, and paint removal demonstrations were observed. One promising piece of equipment was a field tested on a World War II mobilization building at Chanute AFB, IL.

The principles of microwave heating were also researched. Test panels using paint conforming to Federal specifications were prepared and tested in a microwave oven. In addition, samples of old painted wood from demolished mobilization buildings were obtained and tested by the same method.

2 TEST AND DEMONSTRATIONS

Types of Equipment Evaluated

Commercially available equipment from three manufacturers was evaluated: a high-pressure water/sandblasting system (Tritan Corporation and Eastern Equipment and Chemical Company); a steam-propelled sandblasting system (Eastern Equipment Company); and a high-velocity hot air system (Prismo Corporation). These systems were selected because they were potentially faster than the traditional torch-and-scrape technique of paint removal and because manufacturers claimed they could be used to clean wood surfaces. In addition, a study of microwave paint removal from wood specimens was conducted in the laboratory.

High Pressure Water/Sandblasting Equipment

The Tritan Corporation, Houston, TX, demonstrated a high-pressure water/sandblast system that produced water pressures in the range of 7000 psi (4.83×10^7 Pa). The system was developed as an acceptable clean air alternative to sandblasting and steam cleaning. It was designed to clean both soft materials such as grease and grime, and hard and brittle substances such as boiler scale rust and hardened chemical deposits. The Appendix describes the high-pressure water system and its potential uses.

Paint was removed from steel, concrete, and wood substrates during the Tritan demonstration. The experiment on wood consisted of removing paint from a sawhorse that had considerable paint build-up (Figure 1).

The Eastern equipment and Chemical Company, Columbia, SC, also demonstrated a high-pressure water/sandblasting system. The Eastern equipment was of a much lower pressure range, 1500 psi (1.03×10^7 Pa). The test consisted of removing paint from a steel, concrete, and wood substrate (Figure 2).

Because of favorable results from the Eastern equipment demonstration, investigators rented a unit and conducted field tests on a World War II mobilization building at Chanute AFB, IL. The selected building had numerous layers of paint (up to 60 mils [1.5mm] thick) which were peeling from an large percentage of the building. The test was conducted at a water pressure of 1500 psi (1.03×10^7 Pa) using 2.6 grade flintshot as a blasting media. A 1 m^2 area was thoroughly cleaned to determine the effectiveness of the equipment and the quantity of sand and time required (Figure 3).

Figure 1. Tritan Corporation's high-pressure water/sandblasting system demonstration.

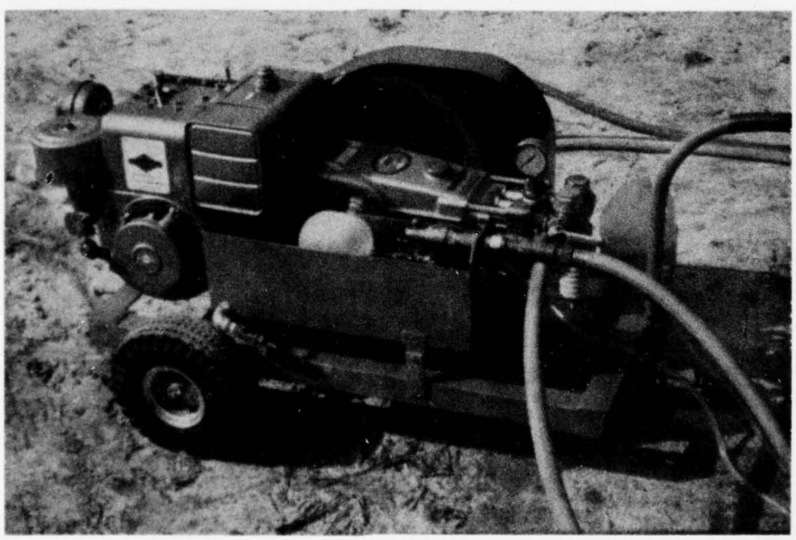

Figure 2. Low-pressure *Hydrosander* by Eastern Equipment and Chemical Co.

Figure 3. *Hydrosander* being used to clean World War II mobilization building.

Steam-Propelled Sandblasting Equipment

The Eastern Equipment and Chemical Company also demonstrated a steam-propelled sandblasting system (Figures 4 and 5). The test consisted of removing paint from steel, concrete, and wood substrates.

Hot Air Torch

The American sales office of Prismo Corporation, a British company which produces a high-velocity (3000 ft/sec [915 m/sec]) hot air (3000°F [615°C]) torch system, was contacted. The system uses a combination of propane and compressed air. The manufacturer conducted tests on painted wood samples to determine the feasibility of adapting the system to paint removal.

Microwave Heating

No commercial equipment is available to remove paint with microwaves, although such equipment could be devised. Specimens were prepared and tested in a standard, commercially available microwave oven intended for home use.

Prior to selecting this approach, a literature search was conducted to determine the principles of energy transfer through microwaves and the feasibility of using microwaves for paint removal.

According to Copeson[1], materials react to microwaves three different ways -- as reflectors, as absorbers, or simply as transparent to microwaves. Metals are good examples of reflectors. They are used as interior liners of microwave ovens to contain the microwaves and keep them confined to the heating area. Ceramics, glass, plastics, and paint films are all essentially transparent to microwaves and are not affected by microwave energy passing through them. The third type of materials, absorbers, depend on molecular configuration to determine the amount of microwave energy they will absorb.

Although an explanation of the chemistry of the process is beyond the scope of this report, the property which determines the amount of energy absorbed is the polarity of the molecule; highly polar molecules, such as water, absorb more microwave energy than less polar molecules. Absorbtion of microwave energy results in the absorbing material being heated. Thus, microwaves will heat the water and pitch found in a wood substrate, drive them out, and, theoretically, lift the paint film from the substrate.

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[1]Copeson, David A., <u>Microwave Heating</u>, 2nd ed. (Avi Publishing Co., 1975).

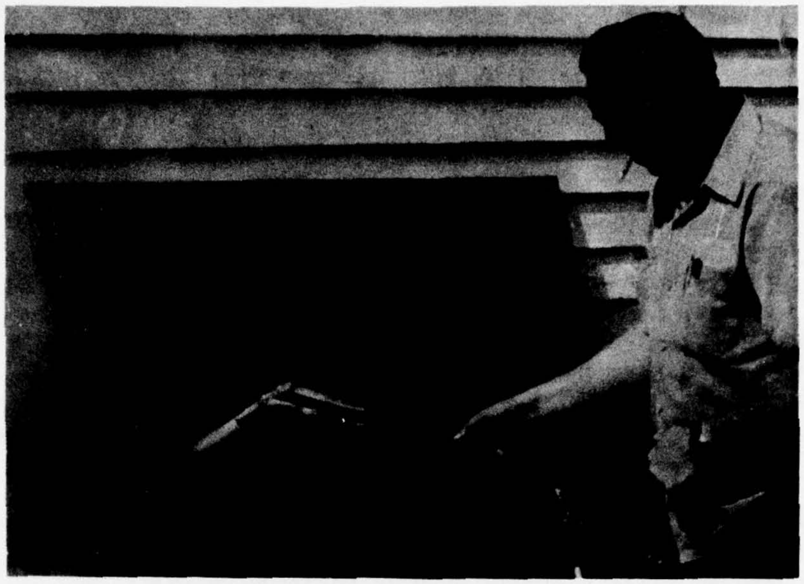

Figure 4. Steam-propelled sander.

Figure 5. *Steam Sander* by Eastern Equipment and Chemical Co.

Preparation of Test Specimens

The initial test specimens were prepared by coating Douglas fir, white pine, and yellow pine blocks approximately 3-1/2 in. square by 3/4 in. (88 mm^2 x 18 mm) thick with primer conforming to Federal Specification TT-P-25. Half of each 3-1/2 in. square (88 mm^2) face was coated; two coats of exterior house paint were then applied. Twenty-four hours drying time was allowed between coats. The paints used conformed to Federal Specifications TT-P-19, TT-P-103, TT-P-105, and Military Specification MIL-P-52324. (Facilities engineers have commonly used these paints for exterior wood siding over the past 25 years.) The specimens were air dried for 60 days.

In addition, several samples of old, painted wood were obtained from Chanute AFB. The samples were in a variety of sizes and shapes and were coated with various types of unknown paints. Also, six samples of heavily coated (up to 1.25 mm paint thickness) yellow pine exterior siding were obtained from mobilization buildings at Fort Campbell, KY, Fort Jackson, SC, and Fort Knox, KY.

Each of the wood samples was prepared in duplicate. One set of samples was dried at 120°F (33°C) for 48 hours. The other was soaked in water for 24 hours. Since precise moisture control is difficult -- and, in terms of duplicating field conditions, probably meaningless -- the two extremes of dry and saturated were chosen for test purposes.

Exposure time for microwave heating was determined experimentally. Dry wood began to char and produced detectable smoke after 53 seconds of microwave exposure. Therefore, 53 seconds was chosen as the maximum microwave exposure time.

3 DISCUSSION AND ANALYSIS OF TEST RESULTS

High Pressure Water/Sandblasting Equipment

The 7000 psi (4.83×10^7 Pa) water/sandblasting equipment demonstrated by Tritan Corporation literally destroyed the painted and plain wood samples tested. The system did, however, readily remove paint from both steel and concrete with minimum damage to the substrate.

The Eastern demonstration of the 1500 psi (1.03×10^7 Pa) water/sandblasting system indicated that it effectively removed paint from wood, steel, and concrete substrates. Unlike the high-pressure system demonstrated by Tritan Corporation, the low-pressure system did very little, if any, damage to the wood substrate. (However, it should be noted that the wood used in this test was very hard and covered with a very thin paint film.)

The Eastern 1500 psi (1.03×10^7 Pa) water/sandblasting system used on the mobilization structure at Chanute AFB removed loose paint readily, but the angle of attack was critical to producing maximum force of the water/sand stream. The equipment seemed to work as well for removal of loose, peeling paint <u>without</u> sand in the water stream as it did <u>with</u> sand in the water stream.

A 1 m^2 area on the mobilization structure was selected and cleaned as thoroughly as possible. The amount of sand and length of time required to accomplish maximum cleaning were recorded. More than 400 lb (18.12 kg) of sand were used to clean 80 percent of the area; the remaining 20 percent consisted of small areas of very hard paint which could not be removed. Approximately 1/2 hour was required to achieve 80 percent cleaning (Figure 6).

The paint on the wooden siding of the mobilization structure proved very difficult to remove by this method. The paint film, being harder than the wood substrate, eroded very slowly while the wood eroded rapidly once the paint film had been worn away. In addition, the wood appeared to provide a cushion that reduced the effectiveness of the impact of the abrasive.

Removal of paint from harder substrates, however, was quite effective. Paint was rapidly and effectively removed from a brick chimney and concrete pavement markings, with minimal erosion of either substrate.

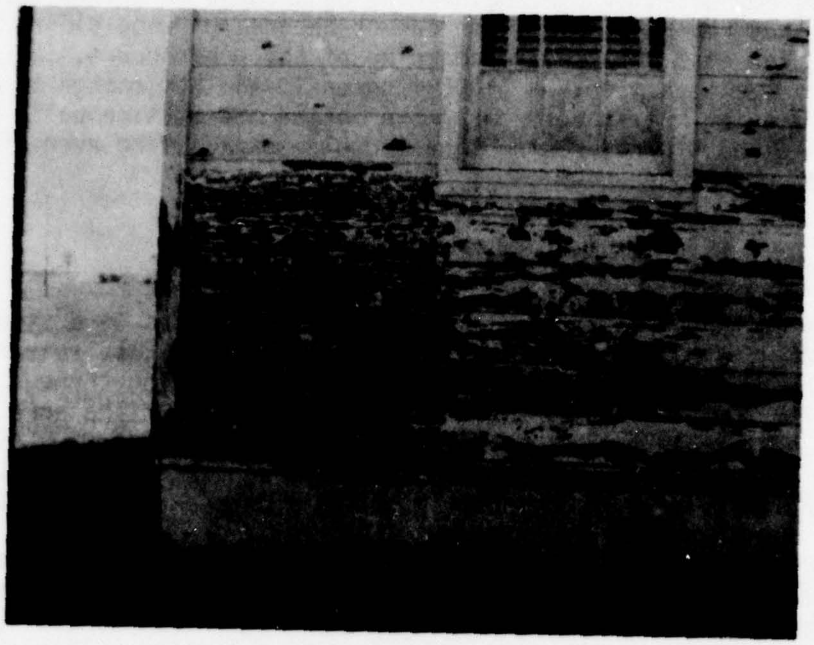

Figure 6. One-square-meter area of building after cleaning.

Steam-Propelled Sandblasting

The demonstration of the steam-propelled sandblasting system proved that the method was extremely slow, regardless of the substrate under test. Therefore, no further evaluation of this method was made.

Hot Air Torch

Tests conducted by the Engineering Department of Prismo Corporation indicate that their hot air torch cannot be used on wood siding for the following reasons: (1) severe charring of the wood occurs, (2) at the high air velocities involved (1000 m/second), air hot enough to start a fire could enter the space between the inside and outside walls through the laps in the siding; residual heat could spark a fire even after the torch had ceased operation.

Microwave Heating

None of the newly prepared painted wood specimens were significantly affected by microwaves in preliminary tests. Results varied from no visible effects on the paint film, to pitch bleeding through an intact film, to blistering over the entire painted surface area of the specimen. Blisters ranged from 1/16 in. (1.8 mm) to 3/4 in. (19 mm) diameter (see Figures 7 and 8). The specimens prepared for testing were of new, relatively thin film, and thus had a degree of flexibility.

The samples from World War II mobilization buildings at Chanute AFB were coated with old, brittle, fully cured paint films. The samples had many coats of paint in thicknesses up to 1.5 mm. The Chanute specimens were only marginally affected by the microwave heating. They exhibited some random blistering which, in most cases, occurred between coats (Figure 9). Specimens greater than 1-mm thick were, for the most part, not affected.

The yellow pine specimens obtained from Forts Campbell, Jackson, and Knox, however, exhibited the greatest degree of successful paint removal. The microwave heated and softened the paint film so that it could be easily removed from the substrate with a scraper (Figure 10). The microwave heating of water and pitch in the wood substrate softened the paint film enough to allow its easy removal.

The tests discussed above were performed on saturated wood siding. However, when dry wood siding specimens were heated by microwave for 53 seconds, a spot on the wooden surface was charred. The gases from the decomposition products of this charring caused the paint film to lift in one large blister over the charred portion. Heat produced at the

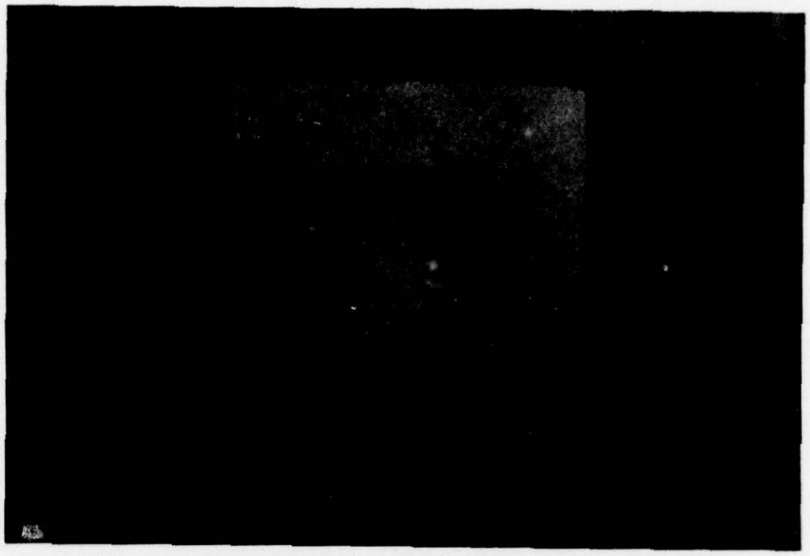

Figure 7. Newly painted wood specimen minimally affected by microwave heating.

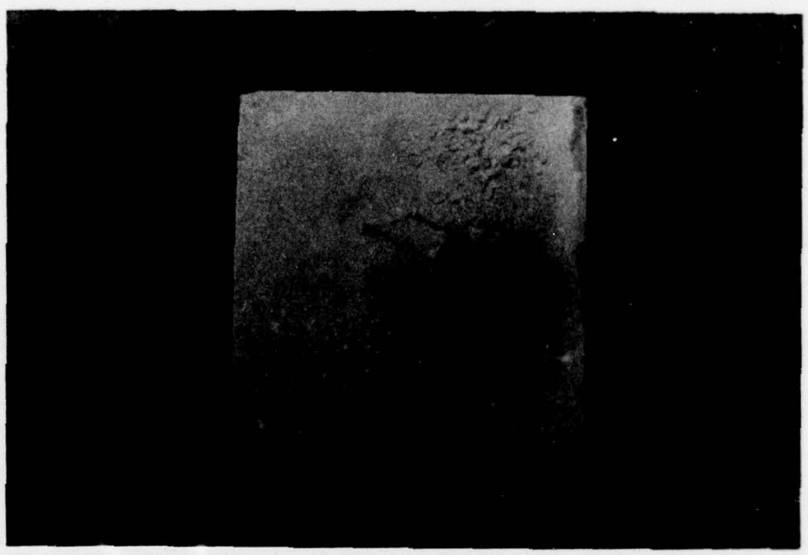

Figure 8. Maximum damage to paint film observed on any newly painted wood specimen.

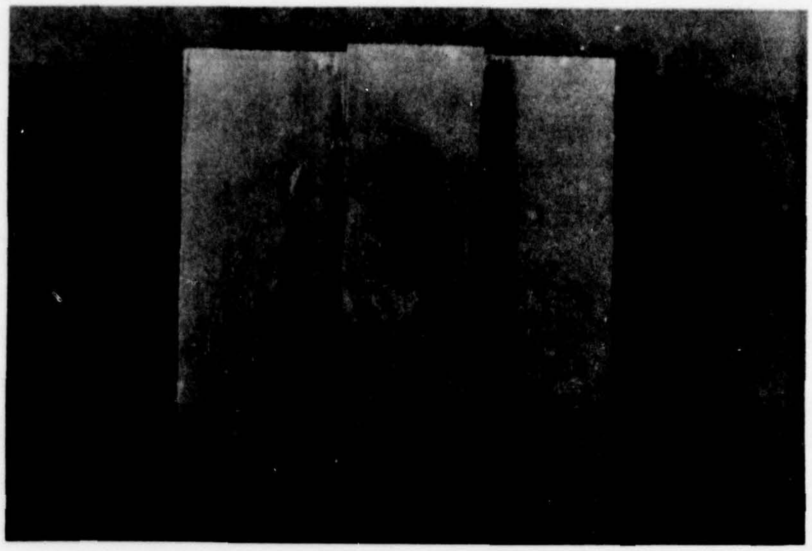

Figure 9. Aged wood specimen from Chanute AFB. Paint blistered between coats.

Figure 10. Multicoat paint film on wood siding specimen peeled back after softening by microwave heating.

wood/paint interface softened the paint film, giving it the flexibility necessary to produce the blister. However, upon cooling, the blister did not shrink down to the substrate again. Instead, it rehardened and remained separated from the wood substrate (Figure 11). This did not occur between the wood and the first coat of paint, but between the first and second coats of paint. (The first coat was very thin and intimately bonded to the wood surface, and was charred simultaneously with the wood.) This charring phenomenon was not produced in the water-saturated wood siding sample.

These tests indicate that microwave heating does not remove old paint any more rapidly or effectively than blow torches or scrapers. In addition, the problems of developing a feasible field-usable microwave system would be substantial, especially in light of the potential safety hazard of the microwave.

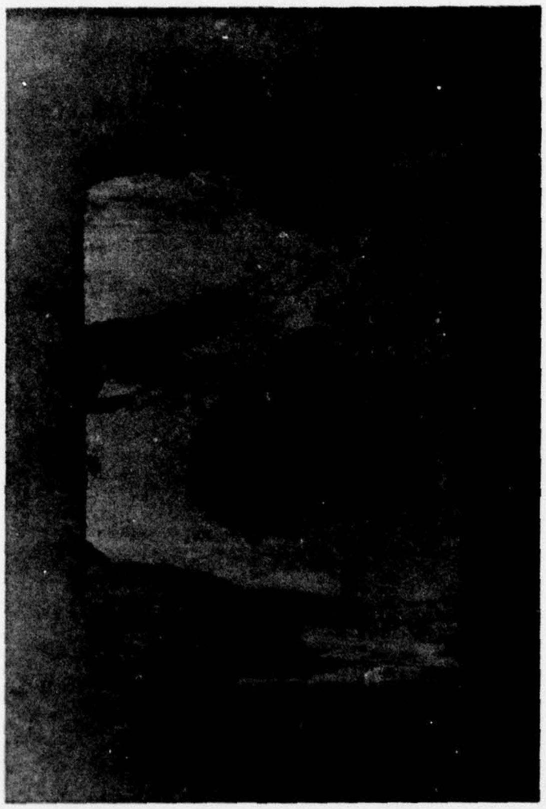

Figure 11. Multicoated dry wood siding specimen with blister removed. Charring of wood evident after microwave heating and removal of paint blister.

4 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of this study indicate that no system has yet been devised that can rapidly remove all the paint from existing wood structures without substantially damaging the wood substrate. The following specific findings can be drawn from this study:

1. The 1500 psi (1.03×10^7 Pa) water/sandblasting system is acceptable for removing paint from a hard substrate such as concrete or masonry. It can also be used to clean painted surfaces and remove some loose paint from wood substrates. It will not remove paint satisfactorily from wood surfaces if complete paint removal is required. The high-pressure 7000 psi (4.83×10^7 Pa) water/sandblasting system severely damages the wood substrate, and thus cannot be used for wood substrate systems.

2. Steam-propelled sandblasting is very slow and generally not economical for rapid removal of paint. Steam sandblasting exhibits no advantages over conventional air-propelled sandblasting or water/sandblasting systems, except that it can remove grafitti with only minor damage to the substrate.

3. The hot air torch causes too much damage to wood substrate and is too hazardous to be considered for paint removal on wooden surfaces.

4. Evaluation of the microwave concept indicates that equipment might be devised that could be effective to some degree, but the method does not show any promise of being more rapid or effective than cleaning with blow torches and scrapers. The field application of microwaves for paint removal would also be a potential safety hazard.

Recommendations

Based on negative results for complete paint removal, it is recommended that the high-pressure water and water/sandblast systems be evaluated to determine their effectiveness only as surface cleaners and removers of loose paint. If the systems are effective and rapid, they may be more cost effective than wire brushing, and provide a better substrate for painting.

APPENDIX: CLEANING AND DESCALING OF MATERIAL WITH HIGH-PRESSURE WATER*

Introduction

Water under pressure is one of the oldest methods of cleaning. The development of reliable high-pressure water pumps has advanced the technology of hydroblasting in the past few years to a practical, cost-saving process that maintenance management personnel should carefully evaluate.

Production and design of high-pressure water pumps have improved to the degree that this equipment has become as maintenance free and long-lasting as high-quality internal combustion engines. Extensive use of high-strength, corrosion-resistant stainless steel alloys has made this possible.

It is necessary to differentiate between high-pressure cleaning and hydroblast equipment. High-pressure cleaners operate in the pressure range of 300 to 1200 psi. They have chemical injection systems that mix specific amounts of cleaning agents and can heat water from 130 to 200 °F. These systems provide an excellent means of removing soft contamination such as grease, oil, dirt, and grime found in all types of industry. This equipment generally produces nozzle flow from 2 to 6 gallons/minute (gpm).

A jet of hot water at 800 to 1200 psi and from 3 to 5 gpm flow rate, that contains proper amounts of chemical, will produce high quality cleaning at rates that far exceed conventional steam cleaners. Initial procurement and operating costs compare favorably with steam cleaners.

Hydroblast equipment produces substantially higher forces than high-pressure cleaners. Equipment pressure operates from 2000 to 10,000 psi with flow rates from 5 to 16 gpm. Normal hydroblast operation depends only on the impact force of water for the cleaning action. Chemical injection or heating of water is not generally required with the hydroblast process.

Cleaning with high-pressure water is gaining acceptance in all phases of industry, because it is inexpensive, effective, and safe. The clean air laws that have almost outlawed exterior sandblast operations

*Material taken from B. Engman and R. W. Gronauer, paper presented at the Southern California Section Meeting, Society of Naval Architects and Marine Engineers, San Diego, CA (25 March 1974).
Metric Conversion: 1 psi = 6.894×10^3 Pa; X°C = X°F - 32/1.85;
1 ft = .3048 m; 1 gallon = 3.785 ℓ.

have forced the use of hydroblast as an alternate method of cleaning material and equipment. A small stream of water (10 gpm) producing velocities as high as 1300 ft/second at 10,000 psi, can actually scrape away almost any unwanted deposit.

Although water in itself is not abrasive, the high pressures produce a surface polishing action. If abrasiveness is required, e.g., for removal of firmly bonded paint, small quantities of sand may be injected in the water stream at the nozzle. To minimize the flash rust that occurs on freshly cleaned steel or iron surfaces, a suitable rust inhibitor may be injected to control surface rust until the surface is painted.

Hydroblast Systems

The typical hydroblast system generally consists of the following:

1. High-pressure pump, with stainless steel components in the pressure end of the pump.

2. Power source.

a. Internal combustion engine, gas or diesel, governor-controlled with a power take-off clutch.

b. Electric motor, constant speed.

3. Drive system -- usually multiple V-belt drive coupled to proper-sized sheves to produce pump crankshaft speeds from 300 to 600 rpm. (In the larger units, the drive system is through a multistep transmission and gear reducer.)

4. Pressure relief valve to limit pump pressures within safe operating limits.

5. System splitter that allows two-gun operation where pump pressure and flow is constant when one or two guns are being operated.

6. Dampener to reduce hydraulic shock on pump valves, hose, and equipment.

7. Pressure gauges.

8. High-pressure hose.

9. Hose reels (optional).

10. Cleaning gun and nozzle.

11. A hydrothrottle so operator can increase and decrease engine rpm.

Hydroblast systems are generally limited to pressures not exceeding 15,000 psi and a 15 gpm gun. This has been established as a practical limit for an operator to control the reaction forces created by the cleaning gun.

What Can Be Cleaned?

Anything that can be removed if scraped, brushed, or chipped with light tools can be scoured away by a stream of high-velocity water. Water cleaning is, in fact, superior to most other methods because the water can be directed into corners, blind passages, through porous materials and other places where cleaning with tools would be impractical or even impossible. Only when the bond between the deposit and the surface is unusually tenacious will cleaning with high velocity water not be effective.

For many cleaning jobs, pressure of only 400 to 600 psi will be sufficient. Other industrial applications may require pressure from 2500 to 15,000 psi. Although general guidelines that relate capacity and pressure requirements to different types of cleaning will be formulated, the best balance between volume and pressure must often be determined by tests or experience.

Soft materials such as grease, grime, foams and waxes can be removed quickly with pressures below 1000 psi. Paint and other deposits in booths or on gratings require pressures from 4000 to 10,000 psi depending on the strength of the film. Once the film is broken, however, the water stream can usually lift and remove it rapidly.

Hard or brittle substances can be removed by directing the water at the interface of the deposit and the surface. By lifting, fracturing, and washing away small pieces, water at pressures from 2500 to 10,000 psi can easily break away brittle deposits that have low tensile strengths, such as boiler scale, rust, and hardened chemical deposits.

Such deposits as investment plaster, core sand, and clay can be removed by letting the high pressure stream erode them away. Pressures from 2000 to 3000 psi will thoroughly clean most sand castings.

Other typical applications include cleaning rust and scale from heat-exchanger tube bundles, grease and dirt from the undercarriages of trucks and railroad cars, loose or dead paint from walls, and residue

from glass- or porcelain-lined tanks. The process also easily removes deposits from filter plates, and accumulations from oil and gas lines and storage tanks. Films from oxidized or plated surfaces that might be damaged by scraping are best removed by water blasting. Build-ups on conveyor equipment are economically cleaned.

The cleaning of latex reactors and heat exchangers is becoming more popular and economical by using the Hydro-Laser pumping units that produce 6000 psi at 60 gpm coupled with automatic and programmed cleaning heads.

Techniques for underwater painting are being developed and hydroblasting has proven a practicable method of underwater cleaning.

The applications of hydroblast equipment are only limited by the imagination of the operator. The rapid drilling of holes or trenching in sandstone formations must be seen to be appreciated.

Advantages of Cleaning With High-Pressure Water

Cleaning with high-pressure water offers the following advantages over other cleaning methods: speed, economy, safety, and protection for the substrate.

Downtime for cleaning pressure vessels, tube bundles, and many other pieces of equipment often can be reduced by changing from scraping and chipping to blasting with high-velocity water, whose force continuously loosens foreign deposits and washes them away. Because high-pressure water cleaning combines the impact forces of chipping with the continuousness of scraping, the cleaning is rapid and efficient. For example, irregular surfaces, such as tread plate, can be cleaned far more quickly with water than by scraping or air chiseling.

Cost savings follow from reduced cleaning time. Savings may also be realized from the elimination of dependence on steam, solvents, and power tools. When in cleaning time is reduced by as much as one-fourth, equipment downtime and labor costs can be substantially lowered. Because the hardware for high-pressure washing is reasonably portable, it can be used almost anywhere in a plant.

Because the water will run off, carrying the material that has been removed to a drain or collection filter, much of the clean-up that must follow other methods will be eliminated, which will save additional time.

Many safety factors are built into high-pressure water cleaning. For instance, cold, clean water is substituted for solvents, cleaning compounds, or steam. Because the person doing the cleaning is normally several feet away from the point of water impact, he will be out of the path of flying debris. Nozzle extensions will allow the operator to clean a tank without getting inside it, which eliminates the operator's exposure to toxic fumes or irritating chemicals.

Other people working near the cleaning site are also protected. Because the water's velocity dissipates rapidly, it is relatively harmless 6 to 10 ft away from the nozzle. A "deadman" cutoff valve on the water gun closes immediately when the operator releases it, which assures safety if the gun is dropped.

Because water is nearly incompressible, and piping relatively inelastic, the system pressure will drop immediately if the hose or pipe should rupture, and only a harmless stream of water will flow from the break.

However, a stream of water moving at a velocity sufficiently high for cleaning can do much harm if it hits a person at short range. For this reason, it must be treated with circumspection. Normal precautions, however, such as a face shield, gloves, rubber hat and coat, and heavy shoes will afford protection with reasonable comfort.

High-pressure water is frequently used for cleaning surfaces that might be damaged by mechanical scraping or sandblasting. For example, the Washington Monument was cleaned with high-pressure water to avoid damaging the mortar between the slabs of marble. Plastic, glass-lined and epoxy-coated tanks can also be cleaned without fear of harming the insides.

Cleaning the inside diameter of heat exchanger tubes, reactors, piping, pipelines, etc., is achieved by the use of self-propelled cleaning heads mounted on lightweight all-plastic hose, capable of withstanding 10,000 psi. Pipelines or conduit as long as 500 ft have been cleaned by this method.

Conclusions

Applications for high-pressure cleaning and hydroblasting are unlimited. The growth of this new segment of industry has been spectacular. Manufacturers' instruction manuals adequately describe the maintenance and trouble shooting of their equipment but make few references to the technical aspects of high-pressure or hydroblast cleaning techniques. The knowledge required to produce the optimum cleaning rates, e.g., pressure, volume, type of chemical, nozzle size and type, cleaning distance from top, gun angle, etc., is obtained only be experience and the testing of the many variables involved in the process.

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